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Analysis of the presence of the bottlenose dolphin (*Tursiops truncatus*) along the Italian peninsula in relation to the bathymetry of the coastal band

Abstract - The bottlenose dolphin (*Tursiops truncatus*) is known as a cosmopolitan species with primarily coastal habits. According to various studies carried out along the Italian coasts, this dolphin finds its habitat within the 100-m isobath. The striped dolphin (*Stenella coeruleoalba*), on the contrary, is known as a cosmopolitan, gregarious species with pelagic habits.

On the basis of these premises, the following hypothesis was formulated: if the bottlenose dolphin finds its habitat of choice in waters less than 100-m deep, then its presence along the Italian coast should correlate with the extension of that habitat, that is, with the distance from the coastline to the 100-m isobath. In the case of the striped dolphin which, on the contrary, tends to avoid waters less than 100-m deep, there should be no correlation or rather there should be an inverse correlation with respect to that of the bottlenose dolphin. In order to verify this hypothesis, we compared the geographical distribution of the dolphins stranded along the Italian coast with the bathymetry of the coastal band. The hypothesis was finally confirmed by statistical analysis.

Key words: Italian peninsula, *Tursiops truncatus*, *Stenella coeruleoalba,* habitat, stranding.

Riassunto - Analisi della presenza del tursiope (*Tursiops truncatus*) lungo la costa della penisola italiana in relazione alla batimetria della fascia costiera.

Il tursiope (*Tursiops truncatus*) è noto come specie cosmopolita dalle abitudini prevalentemente costiere. Secondo diversi studi condotti lungo le coste italiane, questo delfino trova il suo habitat entro la batimetrica dei 100 m. La stenella (*Stenella coeruleoalba*), al contrario, è nota come specie cosmopolita, gregaria dalle abitudini pelagiche. Sulla base di tali premesse, si è formulata la seguente ipotesi: se il tursiope trova il suo habitat d'elezione nelle acque di profondità inferiore a 100 m, allora la sua presenza lungo la costa italiana dovrebbe essere correlata con l'estensione dello stesso habitat, ovvero con la distanza dell'isobata dei 100 m dalla linea di costa. Nel caso della stenella, che al contrario tende a evitare acque di profondità inferiore ai 100 m, tale correlazione dovrebbe venire a mancare ovvero dovrebbe esistere una correlazione inversa rispetto a quella del tursiope. Per verificare tale ipotesi, sono stati messi a confronto i dati relativi alla distribuzione geografica degli spiaggiamenti di delfini lungo la costa italiana con la batimetria della fascia costiera. L'ipotesi è stata infine confermata dai risultati statistici.

Parole chiave: penisola italiana, *Tursiops truncatus, Stenella coeruleoalba*, habitat, spiaggiamento.

Introduction

The bottlenose dolphin (*Tursiops truncatus* Montagu, 1821) is known as a cos-

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mopolitan species with primarily coastal habits (Pilleri & Gihr, 1969; Cagnolaro *et al.*, 1983; Notarbartolo di Sciara & Demma, 1994). During the '60s, morphological differences among populations led to up to 20 different species of bottlenose dolphin being classified (Hershkovitz, 1966). Subsequent reviews of the genus led most authors to combine all forms in a single species, *Tursiops truncatus*, although a second species of Indo-Pacific distribution, *Tursiops aduncus* (Ehrenberg, 1833), is still the subject of debate (Mitchell, 1975; Ross & Cockcroft, 1990; Wilson & Reeder, 1993; Rice, 1998; Hale *et al.*, 2000).

Various authors pointed out the existence of two species ecotypes, one having typically coastal habits and the other having pelagic habits, in various areas of the world (Ross, 1977, 1984; Walker, 1981; Duffield *et al.*, 1983; Van Waerebeek *et al.*, 1990; Hersh & Duffield, 1990; Mead & Potter, 1995; Hoelzel, 1998). The coexistence of these two ecotypes would explain the bimodal distribution of the bottlenose dolphin in relation to the bathymetry, with dolphins distributed either on the shelf or on the shelf edge, as observed by Kenney off the northeaster United States (Kenney, 1990) and by Davis and co-authors (Davis *et al.*, 1998) and by Baumgartner and co-authors (Baumgartner *et al.*, 2001) in the Gulf of Mexico. However, not all the authors seem to attribute the same importance to this bimodal distribution. Davis and co-authors, studying Cetacean habitat in the northern oceanic Gulf of Mexico, also reported a strong attitude of the bottlenose dolphin to live in the continental shelf, in relatively shallow water, independently by other hydrodynamic features influencing the distribution of pelagic Cetaceans (Davis *et al.*, 2002). In this respect, the bathymetry seems to be the main feature characterising the habitat of the bottlenose dolphin. This could be due to the feeding habit of this species, which preys mostly on benthic and demersal fishes (Voliani & Volpi, 1990; Orsi Relini *et al.*, 1994; Silva & Sequeira, 1997; Mioković *et al.*, 1999; Blanco *et al.*, 2001; Santos *et al.*, 2001).

No differing ecotypes of bottlenose dolphin have been described in the Mediterranean Sea. According to Notarbartolo di Sciara (Notarbartolo di Sciara & Demma, 1994) the Mediterranean population is more related to the inshore ecotype because of its coastal habits, while Cañadas and co-authors, reporting the distribution of the bottlenose dolphin off southern Spain, suggest a closer link with the offshore Atlantic ecotype, since most of the bottlenose dolphins are sighted in intermediate depths, lying beyond the continental shelf (Cañadas *et al.*, 2002).

Long-term research conducted by the authors of the present study between 2001 and 2004, within a study area of the Genovese coast that is divided in two by the 100-m isobath, shows that sightings of bottlenose dolphins generally occur within the 100-m isobath, while sightings of striped dolphins (*Stenella coeruleoalba* Meyen, 1833) are usually distributed beyond the 100-m isobath. In this respect, the 100-m isobath seems to be a good approximation of the habitat border between these two species (Fig. 1; Caltavuturo *et al.,* 2005). Various other studies carried out along the Italian coast point out the same inclination of the bottlenose dolphin to live in very shallow waters, within the 100-m isobath (Lauriano, 1997; Pace *et al.*, 1998; Tringali & Puzzolo, in press).

On the basis of these last reports, the following hypothesis was formulated: if the bottlenose dolphin finds its habitat of choice in waters less than 100-m deep, then its presence along the coast should correlate with the extension of this habitat, that is, with the distance from the coastline to the 100-m isobath. In the case of the striped dolphin which, on the contrary, tends to avoid waters less than 100-m deep, there should be no correlation or rather there should be an inverse correlation with respect to that of the bottlenose dolphin.

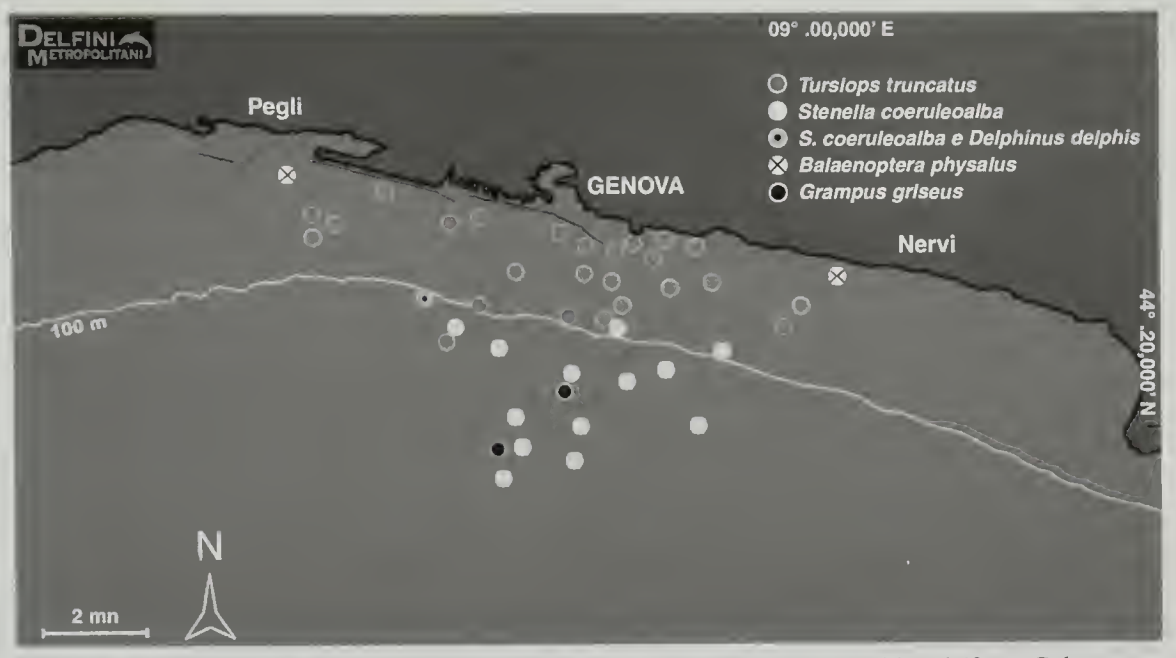

Fig. 1 - Geographical position of Cetacean sightings in the Genovese coastal band (from Caltavuturo *et al.*, 2005).
Fig. 1 - Posizione geografica degli avvistamenti di Cetacei nella fascia costiera genovese (da Caltavuturo *et al.*, 2005).

Materials and methods

The coast of the Italian peninsula, about 3,830 km in total, was arbitrarily subdivided into 20 stretches, each about 185-km long (100 nautical miles) plus one stretch 121-km long (corresponding to the Gulf of Trieste) (Fig. 2).

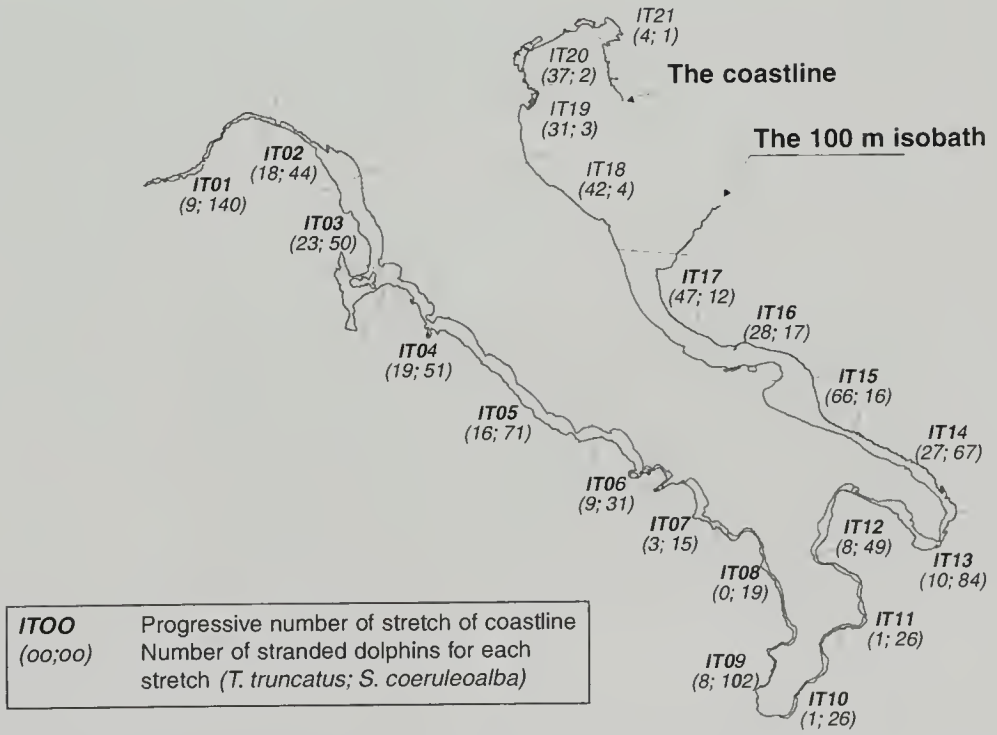

Fig. 2 - The coast of the Italian peninsula has been subdivided into 21 stretches.
Fig. 2 - La costa della penisola italiana è stata suddivisa in 21 tratti.

For each stretch, the flat surface between the 100-m isobath and the coastline was calculated through the CAD software programme MicroStation Bentley (Tab. 1). This surface was defined as "available space" (AS), meaning the sea space usable (but not necessarily used) by the bottlenose dolphin (and avoided by the striped dolphin).

The northern Adriatic Sea, where the water is always less than 100-m deep, was not included in the analysis (see the discussion). Only 17 stretches of coast (approximately 3,150 km in total) were therefore considered for analysis, from Imperia to Civitanova Marche (Ancona) (Tab. 1).

Data relative to stranded Cetaceans along the Italian peninsula supplied by the Centro Studi Cetacei annual report between 1986 and 2002 (Centro Studi Cetacei, 1987-2004) were used as an index of the abundance of dolphins in the corresponding coastal band (see the discussion) (Tab. 1).

Tab. 1 - For each stretch is given the length, the available space (AS), the available space per km, the number of strandings and the number of strandings per 100 km. The highlighted cells point out the values plotted in Fig. 3 and Fig. 4.
Tab. 1 - Per ciascun tratto vengono forniti i dati di lunghezza, spazio disponibile (AS), spazio disponibile per km, numero di spiaggiamenti e numero di spiaggiamenti per 100 km. Le celle evidenziate indicano i valori a confronto in Fig. 3 e Fig. 4.

STRETCHES				STRANDINGS			
IT	length (km)	AS (km^2)	AS/ km	*T. truncatus*	*Tt*/ 100 km	*S. coeruleoalba*	*Sc*/ 100 km
IT01	193.23	560.62	2.90	9	4.66	140	72.45
IT02	185.10	1,380.85	7.46	18	9.72	44	23.77
IT03	184.95	2,279.92	12.33	23	12.44	50	27.03
IT04	184.79	1,544.90	8.36	19	10.28	51	27.60
IT05	185.31	2,180.71	11.77	16	8.63	71	38.31
IT06	185.28	1,334.21	7.20	9	4.86	31	16.73
IT07	185.24	901.18	4.86	3	1.62	15	8.10
IT08	185.35	578.17	3.12	0	0.00	19	10.25
IT09	185.43	335.51	1.81	8	4.31	102	55.01
IT10	185.20	473.27	2.56	1	0.54	26	14.04
IT11	185.32	583.59	3.15	1	0.54	26	14.03
IT12	185.36	877.79	4.74	8	4.32	49	26.44
IT13	185.26	1,535.36	8.29	10	5.40	84	45.34
IT14	185.16	1,987.92	10.74	27	14.58	67	36.18
IT15	185.27	3,308.59	17.86	66	35.62	16	8.64
IT16	185.27	4,086.48	22.06	28	15.11	17	9.18
IT17	185.21	4,491.93	24.25	47	25.38	12	6.48
IT18	185.20	-	-	42	22.68	4	2.16
IT19	185.25	-	-	31	16.73	3	1.62
IT20	185.37	-	-	37	19.96	2	1.08
IT21	121.41	-	-	4	3.29	1	0.82
TOT	3,833.96			407	220.68	830	445.26

The AS per km and the number of dolphins stranded/100 km on the corresponding stretch of coastline were compared by means of statistical correlation test (Spearman rank correlation test) (Tab. 1).

Results

The Spearman rank correlation test pointed out a significant, positive correlation between the number of bottlenose dolphins stranded/100 km in each stretch of coastline and the AS per km in the corresponding stretch (r=0.894; P<0.000001) (Fig. 3).

The same test pointed out a slightly (not meaningful) negative correlation between the number of striped dolphins stranded/100 km in each stretch of coastline and the AS per km in the corresponding stretch (r=-0.311; P=0.1) (Fig. 4).

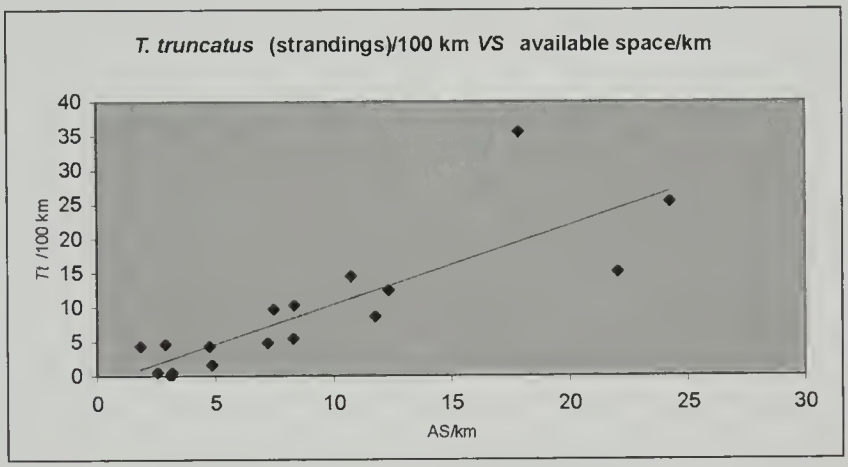

Fig. 3 - The number of bottlenose dolphins stranded/100 km against the available space (AS) per km (Spearman rank correlation coeff. = 0.894; P<0.000001).
Fig. 3 - Il numero di tursiopi spiaggiati/100 km a confronto con lo spazio disponibile (AS) per km (coefficiente di correlazione di Spearman = 0,894; P<0,000001).

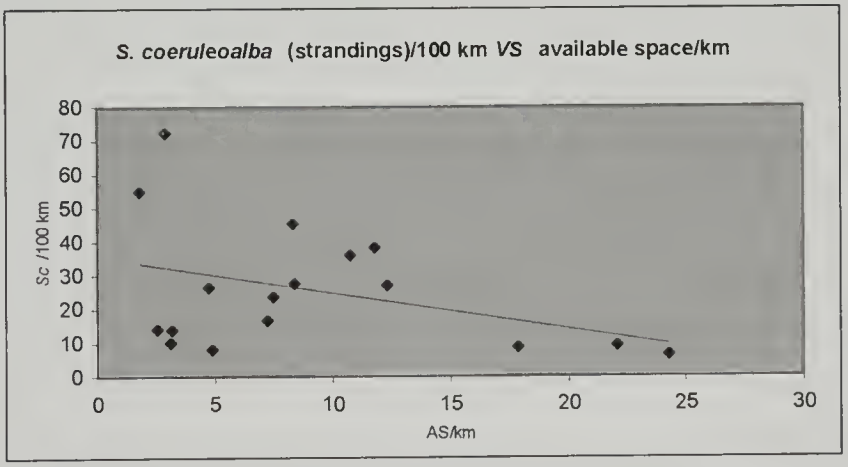

Fig. 4 - The number of striped dolphins stranded/100 km against the available space (AS) per km (Spearman rank correlation coeff. = -0.311; P = 0.112).
Fig. 4 - Il numero di stenelle spiaggiate/100 km a confronto lo spazio disponibile (AS) per km (coefficiente di correlazione di Spearman = -0,311; P = 0,112).

Discussion

The statistical analysis confirms the initial hypothesis. There is a highly significant, positive correlation between the number of bottlenose dolphins stranded on each stretch of coast and the size of the corresponding AS.

Of course diverse variables may influence the number of animals stranded on a given stretch of coastline (prevailing wind conditions, marine currents, coastal configuration, etc.), while other variables may influence the probability for a stranded animal to be found and registered (again the coastal configuration, the presence or absence of anthropic activity along the coast, the efficiency and capillarity of the stranding network, etc.). Still, the number of stranded animals over a long period of time can be used as an index of the abundance of free ranging specimens in the contiguous sea area, especially in case of Cetaceans having coastal habits, as pointed out by McFee & Hopkins-Murphy (2002) with the bottlenose dolphin and by Ferreira & Roberts (2003) with the Maui's dolphin (*Cephalorhynchus hectori maui*) a subspecies of the Hector's dolphin (*Cephalorhynchus hectori* Van Beneden, 1881). Orsi Relini (2001) has used the number and distribution of fin whale neonates (*Balaenoptera physalus* Linnaeus, 1758) stranded along the coasts of the Ligurian and the North Tyrrhenian Sea as an index of the breeding activity of the same species in the open Ligurian Sea.

The present study analyses the stranding data coming from a long period of time (17 years) and points out an extraordinarily high correlation between the number of stranded bottlenose dolphins in each stretch of coast and the size of the corresponding AS. Of course this correlation could be indirect, meaning that other factors, still associated with the 100-m isobath, may have worked in order to produce the expected result without a direct link between the two variables analysed. In order to test this, we have used the striped dolphin as a natural control, since this species tends to avoid waters less than 100-m deep. Since the striped dolphin is not present in the northern Adriatic sea, where the water is always less than 100-m deep (Cagnolaro *et al.*, 1983; Notarbartolo di Sciara & Demma, 1994; Azzali *et al*, 1994), this area was excluded from the analysis.

As hypothesized, no positive correlation was observed between the number of striped dolphins stranded in each stretch of coast and the size of the corresponding AS, while a slightly (not significant) negative correlation was observed. This second result supports the hypothesis that the correlation between the number of stranded bottlenose dolphins in each stretch and the size of the corresponding AS is due to a greater presence of free ranging specimens as the AS increases. The high correlation coefficient suggests that the bottlenose dolphins use the AS with a regular, predictable pattern. Speculating on the mechanism enabling such a rational distribution, we suggest this could be reached through a continuous flow of individuals between contiguous populations by means of a mechanism resembling the communicating vessels.

If confirmed by further studies, the results of the present report could give an important contribution in developing a rational conservation policy for the bottlenose dolphin in the Mediterranean Sea.

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